SOME ANALYSES OF TWENTIETH CENTURY LANDING STATISTICS OF MARINE SHRIMP OF THE SOUTH ATLANTIC AND GULF STATES OF THE UNITED STATES

by

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ABSTRACT

There is a strong correlation between the total catch of white and brown shrimp with dockside prices on the United States Gulf Coast since 1902, but there is no significant correlation between South Atlantic production and prices, probably because the South Atlantic shrimp stocks have been over-fished since the 1920s. There is no negative or positive correlation between the catch statistics of brown and white shrimp of the United States, and these species seem to be weakly competitive, if at all. There is a significant correlation between the annual production of South Atlantic and Gulf white shrimp, but there is none between South Atlantic and Gulf brown shrimp, possibly because the brown shrimp live generally in deeper water and are not so much influenced by short term variations in climatic conditions as the white shrimp are in shallow water. In furtherance of this idea, there is some indication that the brown shrimp production is less variable than the white shrimp production.

INTRODUCTION

Three species of shrimp of the Family Penaeidae (Genus *Penaeus*) are present in considerable numbers and in overlapping distributions in the bays and oceanic shallow waters from Cape Hatteras, North Carolina, south to Texas and beyond. These are the white shrimp *Penaeus fluviatilis*, the brown shrimp *P. aztecus*, and the pink shrimp *P. duorarum*.

Another shallow water penaeid *Penaeus brasiliensis* exists only in such small numbers off Miami, Florida that it was overlooked by biologists of the area until discovered there by Eldred (1960). A fifth species of the Penaeidae, *Xiphopeneus kroyeri*, is almost entirely shallow oceanic in distribution with a few entering the bays in cool weather (Gunter 1950). It is not found along the South Atlantic part of the United States in commercial concentrations, but has been fished in the Gulf since boats and seines large enough to fish the shallow offshore waters have been available.

The white shrimp grows to large size in shallow waters of the bays. The other two species of commercial shrimp, *P. aztecus* and *P. duorarum*, do not grow so large in the bays and shallows and do not school as strongly as the white shrimp and the seabob. They also go into deeper waters when they move into the open ocean.

SOME HISTORICAL ANTECEDENTS

Indians caught shrimp with the use of dipnets, seines and leafy weirs such as are still employed in the Rio Soto la Marina, Mexico. Shrimp from the North Carolina waters were caught and transported to the Philadelphia market when Thomas Say (1817) first described the North American white shrimp.

Catch statistics on the commercial fisheries were collected only after the organization of the United States Fish Commission by S. F. Baird and others in 1871. We may assume with complete assurance, however, that shrimp production grew with the increase in population up until recent years. Even in the early part of this century the catching of shrimp was by means of dipnets, seines, and castnets. For this reason only the white shrimp *P. fluviatilis* and the seabob *Xiphopeneus kroyeri* were taken, because they were schooling shrimp. Even so the seabob has been taken in small numbers amounting to about 1.2% of the Gulf catch, (cf. Gunter 1962) partly because of its small size and its open ocean distribution. This shrimp is much more important, relatively, in South American waters (cf. Lindner 1957).

The otter trawl came into use along with motor vessels on the South Atlantic Coast during the period of World War I and spread quickly to the Gulf Coast. This permitted the fishing of deep waters and larger shrimp, which move out as they grow older. Thus, production gradually rose with the increase of demand and the more efficient otter trawl put the large seine crews out of business in Louisiana in the early 1930s.

From 1902 the shrimp production in this country increased into the early 1950s. In the 1940s an extreme drought caused a great shortage of white shrimp, especially in Texas waters, and there fishermen turned to the previously unfished brown shrimp which were caught predominantly at night. Most states had laws against shrimping at night for the protection of the white shrimp, the idea being that they should not be harassed all hours of the twenty-four. The large brown shrimp generally bury in the bottom during the day. Recognition of these facts led to exploitation of the brown shrimp and after the early '50s it has yielded more than the white shrimp. This development began in Texas waters in 1947 and spread quickly to other areas on the Gulf and South Atlantic Coast. Even so, the separation of the brown and white shrimp was not begun in the federal fisheries statistics until

1957. Therefore, we may say that the shrimp production figures used here were comprised almost entirely of white shrimp from 1903 to 1948, with about 1% being seabobs. From 1948 to 1957 there was a period of production when the brown shrimp and white shrimp were not separated. After 1957 these shrimp have been separated in the catch statistics of the South Atlantic and Gulf Coasts. At that time the seabobs were also separated in the statistics.

From 1951 to 1956 inclusive, the heads-off weight of white and brown shrimp produced ranged between 126 and 146 million pounds and in the 1967–71 period it ranged from 125 to 137 million pounds. These are the only years, except for 1963, that the United States shrimp production has ever ranged above 100,000,000 pounds of headless shrimp. The 1951–56 high production was due to the exploitation of the previously unfished population of brown shrimp plus the white shrimp. The more recent high production seems to be due to an increase in the white shrimp population, caused possibly by a recent hyperfertilization of the bays.

DISTRIBUTIONS AND CATCH RECORDS

There are many interesting things about the distribution of the shallow water penaeids along the coasts of the South Atlantic and Gulf states and Mexico, but here we are concerned only with the brown shrimp *P. aztecus* and the white shrimp *P. fluviatilis*, because these two have been the chief commercial producers and they both grow up in estuarine areas. Furthermore the United States population of brown and white shrimp are quite discrete and disconnected from other populations, and we have United States production of these two species unmixed with foreign populations.

The white shrimp population of the United States is divided into two distinct parts. The South Atlantic component runs along the coast from North Carolina with the greatest abundance in Georgia and gives out at about the St. Lucie inlet in south Florida (Gunter and Hall 1963). The second population extends from the west Florida panhandle to Aransas Bay, Texas.

The brown shrimp has roughly the same distribution but it is less numerous on the Atlantic and extends farther south seasonally in the Mexican waters. Its abundance is greater in the salt waters of Texas than that of the white shrimp, which is most abundant in Louisiana because of the lower salinities in that region. In Texas waters brown shrimp are not raised in appreciable numbers farther south than the Aransas–Corpus Christi Bay system, which is connected to the Gulf by Aransas Pass. During the fall both species leave the bays and go to outside waters. Gunter (1962) showed by following the seasonal catch statistics of four areas on the coast that the white and

brown shrimp go south on the Texas coast in the early fall and winter. Some go into Mexico and return in diminished numbers in the spring to Texas waters. Catches made off northern Mexico are returned to United States ports. This movement apparently begins off Galveston Bay and covers a distance of some 400 miles and it is virtually a parallel case to the seasonal north to south white shrimp migration and return from Georgia to the region of Cape Canaveral discovered by Weymouth, Lindner and Anderson (1933) (Lindner and Anderson 1956).

Pink shrimp exist in fair concentrations off North Carolina and in heavy concentrations off the Tortugas. There are also large concentrations in the Bay of Campeche, Mexico, which were formerly fished by Florida, Texas, Cuban, and Mexican fishermen, and adequate statistics are not available. Former United States catch statistics of this species were confused by Florida and Texas boats bringing in Campeche shrimp. Furthermore Gulf and Atlantic catches were confused by shrimpers carrying some shrimp from Tortugas to Atlantic ports. For these reasons we have avoided use of pink shrimp statistics. As grooved shrimp they were mixed with the browns to a small extent in the late 1950s but not enough to vitiate the brown shrimp statistics.

SUMMARY OF THE PROBLEM

The brown and white shrimp both grow up in the bays of the northern Gulf Coast and the South Atlantic states. They have a differential distribution with relation to salinity and season (Weymouth, Lindner and Anderson 1933, Gunter 1950, 1961, Gunter, Christmas and Killebrew 1964). The white shrimp come in and move out later in the year. Furthermore the white shrimp grow to larger size in the estuaries and, therefore, are more heavily fished before they move outside. As a matter of fact the whole shrimp industry grew up in the shallows and gained technical experience on the white shrimp before moving to the open sea.

Because of the overlapping life history of these two species of commercial shrimp, both in time and place, the question has arisen concerning their competition. Therefore, some who have been concerned with shrimp biology have discussed these matters for years, mostly with the suspicion that there was some kind of competition that opposed one shrimp population to the other. These ideas were the genesis of the analyses offered here.

All shrimp statistics used here were taken from the annual Fishery Statistics of the United States and its predecessors, of which the latest issue is Lyles (1969), and preliminary pamphlets.

PRICES AND PRODUCTION

One would think that prices increased with expansion of production, the demand for shrimp, etc., and such is the case where total United States production and price are concerned. The coefficient of correlation, r, for the figures shown in Table 1 is 0.691 with 39 obser-

Table 1.

The Total Catch of White and Brown Shrimp of the Gulf and South Atlantic Coasts of the United States in Thousands of Pounds and the Dockside Value in Thousands of Dollars

Year	Catch in Pounds	Value	Year	Catch in Pounds	Value
1902	10,506	286	1953	145,414	76,267
1908	11,855	408	1954	172,596	60,535
1918	40,632	1,746	1955	156,454	61,404
1923	45,987	2,593	1956	142,297	70,305
1927	64,200	3,518	1957	90,364	72,438
1928	74,986	4,550	1958	89,903	71,829
1929	70,487	4,435	1959	108,548	56,875
1930	57,219	2,996	1960	112,088	66,143
1931	62,628	2,731	1961	64,234	50,589
1932	57,313	2,036	1962	77,788	71,832
1934	77,479	3,067	1963	112,535	68,785
1936	76,520	3,778	1964	95,813	69,328
1937	90,866	5,009	1965	111,643	81,067
1938	96,150	4,848	1966	107,041	93,784
1939	96,150	4,848	1967	137,837	99,584
1940	97,754	5,895	1968	124,480	109,833
1945	122,743	21,289	1969	126,331	117,317
1950	122,048	43,144	1970	139,437	119,569
1951	143,780	51,518	1971	148,125	143,362
1952	145,414	54,755			

vations and 37 degrees of freedom. This means that prices and production have grown together, and the correlation is significant within the 1% level.

A further breakdown shows that the correlation, r, between price and production on the Gulf Coast amounts to 0.737 which is even more significant (Table 2). The Gulf correlation is higher than that of price

Table 2.

The Catch of United States Gulf Coast Brown and White Shrimp in Thousands of Pounds and Thousands of Dollars

Year	Pounds	Value	Year	Pounds	Value
1902	8,031	199	1953	145,781	66,336
1908	8,156	270	1954	153,995	53,652
1918	30,466	1,276	1955	137,923	54,465
1923	30,595	1,771	1956	125,727	62,499
1927	44,725	2,344	1957	74,760	63,288
1928	53,357	3,092	1958	76,992	63,871
1929	50,468	2,986	1959	94,362	50,348
1930	40,203	2,017	1960	94,276	57,631
1931	46,075	1,817	1961	53,574	43,650
1932	42,427	1,400	1962	64,582	60,557
1934	60,621	2,278	1963	103,067	63,539
1936	54,723	2,756	1964	86,139	62,695
1937	73,050	4,181	1965	96,010	70,907
1938	73,108	3,725	1966	93,886	82,971
1939	78,173	3,991	1967	125,862	90,574
1940	83,012	5,141	1968	109,799	95,837
1945	94,444	17,305	1969	110,723	101,131
1950	98,359	33,112	1970	126,897	108,183
1951	125,747	44,136	1971	129,850	123,770
1952	128,745	48,170			

and production of total shrimp, of the South Atlantic and Gulf combined.

In contrast, the correlation between price and total catch on the South Atlantic Coast, Table 3, is 0.067, which is not significant at all. This somewhat anomalous conclusion becomes clear if the shrimp of the South Atlantic Coast were over-fished rather early in the development of this fishery and have been over-fished for years. This explanation was advanced by Mr. Milton J. Lindner, whose experience with the South Atlantic shrimp fishery began in 1930. Examination of Table 3 shows that high production in white shrimp on the Atlantic Coast was attained in the 1920s. Apparently these shrimp were fished to the very limit of their yield and have been for a great number of years. This seems to be the only reasonable explanation of the fact that price level and shrimp production have not increased together on

Table 3.

The Catch and Values of White and Brown Shrimp in Thousands of Pounds and Thousands of Dollars for the South Atlantic

Year	Pounds	Value	Year	Pounds	Value
1902	2,475	87	1953	21,385	9,931
1908	3,699	138	1954	18,601	6,883
1918	10,166	470	1955	18,531	6,939
1923	15,392	822	1956	16,570	7,806
1927	19,475	1,174	1957	15,604	9,150
1928	21,629	1,458	1958	12,911	7,958
1929	20,019	1,449	1959	14,186	6,527
1930	17,016	979	1960	17,812	8,512
1931	16,553	914	1961	10,660	6,939
1932	14,586	636	1962	13,206	11,275
1934	16,858	789	1963	9,468	5,246
1936	21,797	1,022	1964	9,674	6,633
1937	17,816	828	1965	15,633	10,160
1938	17,899	821	1966	13,155	10,813
1939	17,977	857	1967	11,975	9,010
1940	14,742	754	1968	14,681	13,996
1945	28,299	3,984	1969	15,608	16,186
1950	23,689	10,032	1970	12,541	11,386
1951	18,033	7,382	1971	18,275	19,592
1952	16,669	6,585			

the South Atlantic Coast, but have increased together on the Gulf Coast.

It may be further assumed that if the Gulf fishing continues at a high level with a continued price rise, that the production of Gulf shrimp will reach a limit, if it has not already done so, and that in future times price and shrimp production on the Gulf Coast will no longer show a correlation.

PRODUCTION FIGURES BY AREAS AND SPECIES

Because of previous correlations noted between the production of white shrimp and rainfall in the State of Texas (Gunter and Edwards 1969) and the apparent preference of brown shrimp for higher salinities, we determined the correlations between the catch of whites

and browns in the State, r equaled —0.2151, but with only 14 degrees of freedom it was not significant.

Similarly there was no significant correlation between the catch of browns and whites on the South Atlantic Coast, the Gulf Coast, or the total of both areas. This means apparently that the production of these two shrimp are not closely related to one another and that they have different ecological niches and are weakly competitive, if at all.

On the other hand, there is a correlation between the total annual production of shrimp of the South Atlantic with the total annual production in the Gulf, in which r equals 0.3261 with 37 degrees of freedom (Table 4). This is significant at the level of 5.0%. This would mean that when conditions are generally good for shrimp production on the Gulf, they are also good on the Atlantic. Most likely these con-

Table 4.

Comparison of South Atlantic and Gulf Catches of White and Brown Shrimp in Thousands of Pounds

Year	Atlantic	Gulf	Year	Atlantic	Gulf
1902	2,475	8,031	1953	21,355	145,781
1908	3,699	8,156	1954	18,601	153,995
1918	10,166	30,466	1955	18,531	137,923
1923	15,392	30,595	1956	16,570	125,727
1927	19,475	44,725	1957	15,604	74,760
1928	21,629	53,357	1958	12,911	76,992
1929	20,019	50,468	1959	14,186	94,362
1930	17,016	40,203	1960	17,812	94,276
1931	16,553	46,075	1961	10,660	53,574
1932	14,586	42,727	1962	13,206	64,582
1934	16,858	60,621	1963	9,468	103,067
1936	21,797	54,723	1964	9,674	86,139
1937	17,816	73,050	1965	15,633	96,010
1938	17,899	73,108	1966	13,155	93,886
1939	17,977	78,173	1967	11,975	125,862
1940	14,742	83,012	1968	14,681	109,799
1945	28,299	94,444	1969	15,608	110,723
1950	23,689	98,359	1970	12,541	126,897
1951	18,033	125,747	1971	18,275	129,850
1952	16,669	128,745			

ditions are of a broad climatic nature, involving such things as cool and warm years, high rainfall and droughts, and even hard cold waves. It would be quite difficult to get some of these factors into figures or numbers, especially comparable figures for statistical calculations, even if the climatic events were recorded years ago as many were not. Therefore, we will pass this question by.

Similarly there is a very strong correlation between the white shrimp production of the Atlantic Coast and Gulf Coast (Table 5).

Table 5.

Catch Figures for South Atlantic and Gulf White Shrimp in Thousands of Pounds

Year	Atlantic	Gulf	Year	Atlantic	Gulf
1902	2,475	8,031	1945	28,299	94,444
1908	3,699	8,156	1957	9,554	11,129
1918	10,166	30,466	1958	7,204	25,740
1923	15,392	30,595	1959	8,326	24,574
1927	19,475	44,725	1960	12,200	28,381
1928	21,629	53,357	1961	9,113	14,421
1929	20,019	50,468	1962	7,879	23,166
1930	17,016	40,203	1963	4,719	47,087
1931	16,553	46,075	1964	5,272	43,978
1932	14,586	42,727	1965	10,587	33,599
1934	16,858	60,621	1966	5,948	29,917
1936	21,797	54,723	1967	7,020	24,960
1937	17,816	73,050	1968	11,004	30,918
1938	17,899	73,108	1969	10,294	44,959
1939	17,977	78,173	1970	8,111	45,962
1940	14,742	83,012	1971	12,077	42,010

The total series stemming from 1902 to 1971 has 29 degrees of the freedom, because the years 1948 to 1957 were excluded when brown shrimp and white shrimp were not properly separated in the fisheries statistics. The correlation r was found to be 0.655 and significant at the 1% level.

In contrast, no such correlation can be shown between the brown shrimp catch of the South Atlantic and Gulf (Table 6). We may spec-

Table 6.

Atlantic and Gulf Brown Shrimp Production in Thousands of Pounds and the Totals

Year	Atlantic	Gulf	Atlantic and Gulf browns combined
1957	6,050	63,631	69,681
1958	5,707	51,252	56,959
1959	5,860	69,788	75,648
1960	5,612	65,895	71,507
1961	1,547	39,153	40,700
1962	7,164	41,416	48,580
1963	4,749	55,980	60,729
1964	4,402	42,161	46,563
1965	5,046	62,411	67,457
1966	7,207	63,969	71,176
1967	4,955	100,902	105,857
1968	3,677	78,881	82,558
1969	5,314	65,764	71,078
1970	4,430	80,934	85,364
1971	6,060	87,788	93,848

ulate here that brown shrimp spend a shorter time in the bays, and live in deeper water in the ocean, and for that reason would be less affected by climatic variations than the white shrimp in shallower water. Thus production would be less subject to parallel variations induced by climatic variables in shallow water, all leading to greater correlations of the white shrimp catch on the two coasts.

We pursued this idea a little further and compared the coefficient of variation of the brown and white shrimp catches (Table 7). The coefficient of variation for the brown shrimp was 25.918 and for the white shrimp was 28.569. A comparison of the significance of differences between two variants showed that this was significant at the classical 95% level. This means that the brown shrimp production is probably less variable than the white shrimp production on the United States coast, and possibly a longer series of data will clarify this point.

A list of significant correlations determined in this study and a list of correlations which are not statistically significant are given in Tables 8 and 9, respectively.

Table 7.

Total Brown and White Shrimp Catches of the United States in Thousands of Pounds

Year	Browns	Whites
1957	69,681	20,683
1958	56,959	32,944
1959	75,648	32,900
1960	71,507	40,581
1961	40,700	23,534
1962	48,580	29,208
1963	60,729	51,806
1964	46,563	49,250
1965	67,457	44,186
1966	71,176	35,865
1967	105,857	31,980
1968	82,558	41,922
1969	71,078	55,253
1970	85,364	54,073
1971	93,849	54,087

Table 8.

A List of Significant Correlations Determined in this Study

	Degrees of Freedom	r	Significance
1. South Atlantic and Gulf browns and whites vs. values.....	37	0.6912	1.0%
2. Gulf browns and whites vs. values.....	37	0.7368	0.1%
3. South Atlantic browns and whites vs. Gulf browns and whites.....	37	0.3261	5.0%
4. Atlantic whites vs. Gulf whites.....	32	0.6550	1.0%

Table 9.

A List of Correlations Determined in this Study that are not Statistically Significant

		Degrees of Freedom	r
1.	South Atlantic grooved vs. whites	15	-0.003
2.	Gulf grooved vs. white shrimp	16	0.094
3.	South Atlantic browns vs. whites	15	-0.065
4.	Gulf browns vs. whites	16	0.051
5.	South Atlantic and Gulf browns vs. South Atlantic and Gulf whites	13	0.2790
6.	Texas grooved vs. whites	16	-0.148
7.	Texas browns vs. whites	16	-0.215
8.	South Atlantic browns and whites vs. value	39	0.0674
9.	South Atlantic browns vs. Gulf browns	15	0.121

SUMMARY

There are five species of commercial penaeid shrimp extending from Cape Hatteras, North Carolina to northern Mexico. One is localized in Biscayne Bay, Florida and one is only produced in low percentage (less than 2%) of the total catch in the Gulf of Mexico. A third species, the pink shrimp, has had foreign catches so mixed with the domestic production that local figures on the Gulf Coast for past years are not reliable. Fairly adequate production figures for white shrimp are available for the years 1902 to 1947 and 1958 to the present. From 1948 to 1957 the brown and white shrimp catches were mixed and to some extent with the pinks. After 1958 all species were separated in the catch records.

There is a strong positive correlation between total shrimp production of the United States and value (dockside price) of the shrimp, and an even more significant correlation between Gulf production and value. In contrast the much smaller South Atlantic shrimp catch shows no correlation with prices, probably because the stock has been fished to capacity since the 1920s, when production limits seem to have been obtained.

A strong correlation exists between white shrimp production of the South Atlantic and the Gulf, while none was found for the brown shrimp production of the two areas. A possible explanation for this fact is the deeper water distribution of the brown shrimp, which means a more stable environment, less affected by general climatic oscillations which influence white shrimp in shallow waters and cause similar variations in the two populations.

There is no significant correlation between the total United States production of white and brown shrimp, either positively or negatively, nor are there any correlations of the South Atlantic and Gulf areas considered separately. This means that the brown and white shrimp are weakly competitive, if at all.

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